THE TELEGRAPHIC JOURNAL.
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AN OVERLAND LINE TO THE CAPE.

IN our March number we had to consider the question of cable communication between the Cape Colonies of South Africa and Europe, and the respective schemes of Mr. Donald Currie and Sir James Anderson for attaining this end. We have now to review another, and a more striking proposal to the same effect, which emanates from Cape Colony itself. On March 27th last, Mr. Sivewright, the Superintendent of Telegraphs for the Colony, delivered a very interesting lecture on this subject to the members of the Philosophical Society of Cape Town, and unfolded an original scheme, at once practical and daring, for connecting South Africa telegraphically to Europe, not by means of submarine cables, either along the East or West Coast of Africa, but by a land-line running through the heart of the continent. It is conceded on all sides that a telegraph to Europe would greatly benefit the South African Colonies; and the state of feeling with regard to it in these colonies is such as is likely to bring it about before long. The question which will have first to be settled is whether it should be a land-line or a cable. Mr. Sivewright argues against a cable that experience has shown cables to be very short-lived, and altogether insecure property; that a cable from Aden to Natal *viâ* Mauritius would cost, at least, £1,000,000; and that a repairing ship would require to be kept up at an annual cost of £10,000 to £12,000. To raise this vast sum, and maintain the line, would saddle the company with a yearly tax of something like £80,000, and as only £40,000 of this might be expected from the traffic, there would remain a balance of £40,000 to be made up by subsidies from Cape Colony, Natal, and Mauritius. At the present time the Egyptian lines extend to Khartoum in Nubia, at the junction of the Blue and White Niles, and, in a comparatively short time, they will reach as far as Gondokoro, on the White Nile, some two hundred miles below its rise in the Albert Nyanza, lat. 4°. 54′ N. The colonial lines now run as far north as Kimberley and Pretoria, the capital of the Transvaal. From either of these places the distance to Gondokoro, as the crow flies, is 2,000 miles; but a direct route through the centre of the continent, by way of the great lakes, with spur lines to Mozambique, Zanzibar, and other places, is wisely discarded by Mr. Sivewright. His plan is to connect Kimberley or Pretoria to Gondokoro, by a single line wire 2,500 miles long, in three great divisions from Kimberley to Tete, a trading town, up the Zambesi, from Tete to Zanzibar on the coast, and from Zanzibar to Gondokoro. The first division would take in the capitals of several friendly native chiefs, and would pass through well-known territory. The second would take in the mission town called Livingstonia, on Lake Nyassa, and would then follow the route traversed by Livingstone, in his earlier journeys, to near Cape Delgado, and thence to Zanzibar, over country which Dr. Kirk considers both safe and easy. The last division appears likely to prove the most difficult, since it would have to pass through an unexplored region, peopled by unfriendly natives. With Kimberley, Tete, Zanzibar, and Gondokoro as basis of operation, the range of transport for each section need not exceed 400 miles, whereas in constructing the Australian overland line, everything required had to be carried in waggons as much as 1,200 miles. Another point in favour of the scheme is that it includes Zanzibar, an important port of trade in the main route.

A subsequent cable from Aden to Zanzibar would not be a very great undertaking, and it would be an additional security as an alternate line of communication. As regards the construction of the line, Mr. Sivewright naturally does not anticipate any insurmountable difficulties. Bullocks would be employed for transport in regions free from *tsetse* fly, and camels or natives in infested places; indigenous woods would be employed for poles, and where suitable woods failed, iron poles would be used. There would be stations of maintenance every two hundred miles apart, so that breakdowns could speedily be put right. We incline to agree with Mr. Sivewright that the difficulties and dangers likely to arise from marauding monkeys, elephants, and hostile natives, are not of a very deterrent nature, and would probably prove less formidable in reality than might be imagined beforehand. The Prairie Indians have a superstitious reverence for the telegraph, which we must all admit to be very well bestowed, and highly creditable to them as a race. The nomadic Arabs along the Euphrates section of the Indo-European line were brought to look with favour on the wire through the magic of a yearly "backsheesh" to their chiefs; and if the Negro did not constitute the line a fetish of more than ordinary malevolence, he might be brought at least to regard it as a mysterious source of revenue. We do not doubt that the difficulties of construction and maintenance could be successfully overcome as similar difficulties have been overcome before on the Indio-European, the Rocky Mountain, the Trans-Andine, and the Australian lines; but we

have misgivings about Mr. Sivewright's estimate of the total cost. He considers £200 a mile on an average "more than ample to cover all the expenses in connection with the work." For the 2,500 miles this gives a total cost of £500,000, or half the cost of cable. According to the *Cape Argus*, from which we have drawn the details of the scheme, the yearly tax on the company for interest on capital and maintenance would be about £50,000, and taking £25,000 as the proceeds of the traffic, there would be a balance of £25,000 to be raised by subsidies from Cape Colony, Natal, and perhaps the Sultan of Zanzibar and the Imperial Government. If these figures are correct, we think that Mr. Sivewright has made out a good case for his project; but it appears to us that running a line through the dense jungle of the central portions of the continent, where the road has to be made first, and a wide track cleared of bush to keep the trees from encroaching on the line, would swallow up more than £200 per mile. Mr. H. M. Stanley has, we are told, expressed himself strongly against the scheme, characterising it as visionary and impracticable; whereas Col. Grant, on the other hand, has recommended it. Before deciding, therefore, in favour of a land-line, it will be wise to get a more thorough acquaintance with the proposed route; and it would be well if the competing sea routes were sounded also, for experience in cable work has shown that we are too apt to take it for granted that all is smooth and still at the bottom of the sea.

IMPROVEMENTS IN QUADRUPLEX TELEGRAPH APPARATUS.

THE following is a description of an improvement in quadruplex apparatus, made by Mr. Gerritt Smith, and, with the diagram, will give a very clear idea of its operation. It is now in successful use on the lines of the Western Union Telegraph Company, and has been found in practice to work satisfactorily on the longest circuits.

A general plan of the apparatus, including both the transmitting and receiving instruments, is shown in the diagram.

The transmitting devices, both in construction and mode of operation, are similar to those employed in the earlier form of apparatus; consequently, it is only necessary to allude herein to the effect produced upon the line by the operation of two independent transmitters, or keys, when thus arranged, which is as follows:

First.—Key K_1 and K_2 both open. In this position the entire battery is in circuit, sending to the line a negative or — current of — B — 3 B = — 4 B.

Second.—Key K_1 open and K_2 closed. In this case battery B only is in circuit, sending to the line a negative or — current of — B.

Third.—Key K_1 closed and K_2 open. The entire battery is again in circuit, but in this case with the positive or + pole to the line, sending a current of + 3 B + B = + 4 B.

Fourth.—Key K_1 and K_2 both closed. In this position the battery B only is in circuit, sending to the line a positive or + current of + B.

Thus it will be understood that the line is caused to assume four distinct electrical conditions, corresponding with the four possible positions of the keys at the transmitting station.

The receiving apparatus consists of two sounders, S_1 and S_2, which are controlled by relays R_1 and R_2. The construction and mode of operation of the former is the same in every particular as that now in use on the numerous lines of the Western Union Telegraph Company on which the quadruplex system is worked, designated as relay No. 1, and is fully described* in Mr. Prescott's work, *Electricity and the Electric Telegraph*.

The relay R_2 differs materially, however, from the relay R_1 in the arrangement of its local circuit connections, by means of which the sounder S_2 is operated; and the improvement upon the form of relay heretofore used consists chiefly in dispensing with one of the supplementary contact levers, whereby the apparatus is not only simplified, but made to work with greater facility and certainty through long circuits.

The normal position of the apparatus when neither key at the transmitting station is depressed, is that shown in the diagram.

The manner in which the relays R_1 and R_2 operate in each of the four electrical conditions of the line mentioned, so as to cause the sounder S_1 to respond solely to the movements of key K_1, and the sounder S_2 in like manner to the movements of key K_2, and both in response to a simultaneous depression of keys K_1 and K_2, will be understood by reference to the following explanation:

First.—K_1 and K_2 both open. A negative or — current from both batteries (— 4 B). The local circuit of sounder S_1 is kept open, because the polarity of the line current tends to hold the armature *h* of relay R_1 on its back stop *p*. The local circuit of sounder S_2 is also open between armature *j* and lever *r*, because the current on the line is sufficiently powerful to overcome the spring r_1 and hold armature *j* against stop *o*; thus sounder S^2 remains inactive.

Second.—K_1 open and K_2 closed, a negative or — current from battery B only (— B). The local circuit of sounder S_1 remains open between stop p_1 and armature *h*, because the polarity of the current is such as to hold the latter against stop *p*. The action of this current upon relay R, is to cause its armature J, assisted by spring R_1 to move to the left and make contact with the lever *r*, but not with sufficient force to overcome the retractile spring q_1, thus leaving armature J in a central position between stops *o* and o_1, thereby closing the local circuit and operating sounder S.

Third.—K_1 closed and K_2 open, a positive or + current from both batteries (+ 4 B). This current causes the armature *h* of relay R_1 to move to the left, thus closing the local circuit at stop p_1 and actuating sounder S. The armature J of relay R_2 is also strongly attracted towards the left, pressing against the yielding lever *r* with sufficient force

* See TELEGRAPHIC JOURNAL, Jan. 1, 1876.

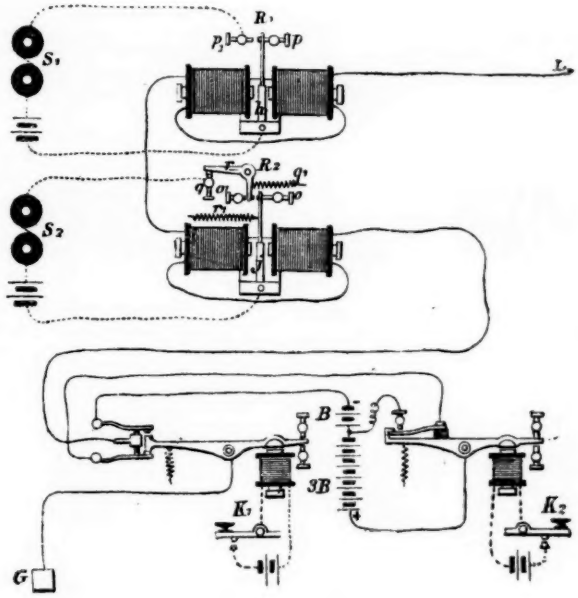
to overcome the spring q_1, and press the former against the stop o_1, thus opening the local circuit of sounder S_2.

Fourth.—Keys K_1 and K_2 both closed, positive or + current from battery B only (+ B). Relay R_1, which is arranged to close its local circuit by positive currents of any strength, actuates the sounder S_1 precisely as in the third case. The current upon the line in this case is not of sufficient strength to hold the armature J of relay R_2 against stop o_1, consequently it moves, together with lever r, assisted by spring q_1, to a central position, thus closing the local circuit between armature J and stop q through lever r, thereby operating sounder S_2. When the armature J of relay R_2 passes directly over from one extreme position to the other, for example, from stop o to o_1, it will be observed that the local circuit is closed for an instant, but not long enough to produce any effect whatever upon the lever of sounder S_2.

It is therefore obvious that, with the apparatus arranged as herein illustrated and described, two communications may be simultaneously transmitted over a single conductor, and the signals recorded with facility and accuracy.

In order that four communications may be made to pass simultaneously over a single conductor, it is only necessary to combine the apparatus herein described with any suitable one of the several known methods of simultaneous transmission in *opposite* directions. The arrangement in general use for the accomplishment of this purpose upon the Western Union Telegraph Company's lines, is known as the differential method. A system of duplex telegraphy, known as the bridge method, may be used instead of the differential, or, instead of either of these, a combination of the differential and bridge methods. In practice the latter has been found preferable, more especially on the longer circuits, where the signals have to be re-transmitted automatically over an adjoining circuit, in which case it is absolutely essential that the signals should be recorded perfectly at the repeater station.

The last-named plan is in operation on the New York and Chicago quadruplex circuit, arranged so that signals from New York and Chicago are at Buffalo automatically re-transmitted in either direction.—*Journal of the Telegraph.*



A CLOSED CIRCUIT TRANSLATOR.

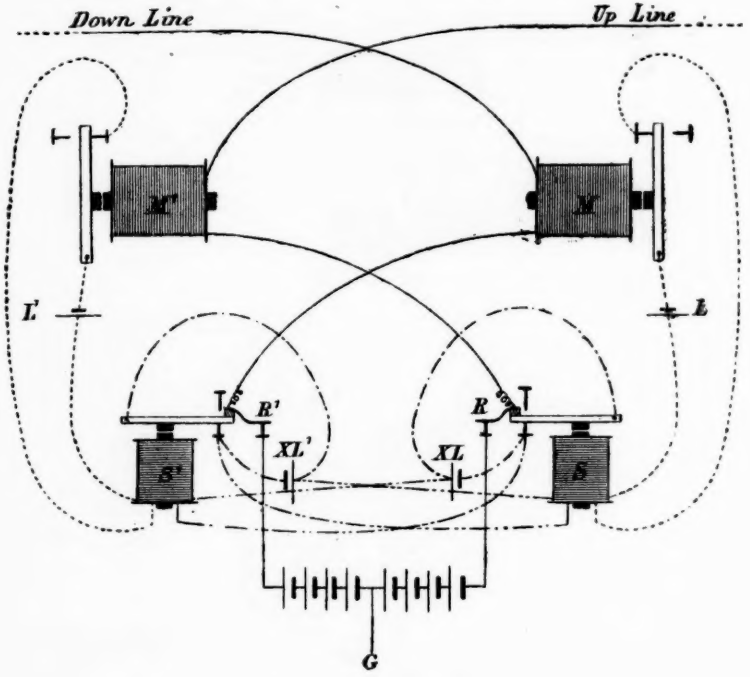
By S. M. BANKER.

THE difficulty with which we have to contend with in a closed circuit translator or repeater, consists in having to keep closed the repeating point belonging to, and forming a part of, the circuit of that side which is sending, and at the same time to keep it perfectly under the control of the other or receiving side.

In the Figure it will be seen that each side of the repeater consists of an electro-magnet M, M^1, and sounder S, S^1, only; and the distinctive feature of the arrangement is, that only the sounder is required

to undergo any change of construction from those in ordinary use, each sounder, S, S^1, having its coils double wound with the same size wire and of the same resistance for two separate circuits, and the armature lever having an insulated spring contact for making and breaking the line circuit.

Now, when an "up" station, for instance, wishes to break, it will be seen that the circuit passes through M^1 on to repeating point R of sounder S to the main battery, and so to earth: hence, on "up" breaking the circuit, the armature of M^1 falls off the local circuit contact by means of an antagonistic spring, and in consequence the armature lever of S^1 rises off its lower stud, breaking the "down" circuit at the repeating point R^1; this last action causes the lever of M to break the local circuit L through the sounder S, and the rising of its armature lever would break the "up" circuit also at the point R but for the following device:—Each sounder is provided with a second local for the second circuit through its coils, and this second circuit can be diverted or cut off from the coil by means of the armature lever of the opposite sounder. Suppose that both sounders are closed, the lines being in their normal condition, the extra local batteries X L, X L^1 are on short circuit through levers of sounders; but when either sounder lever rises—the circuit through this route being broken—the current then passes through the coil of opposite sounder holding down the armature as a consequence of the resistance through the lever being very small compared with the resistance through the coil; so we see that, when "up" breaks, the action of the sounder S^1 is first to break the local circuit X L^1, sending the current from X L^1 through the second coil of sounder S, and then to break the "down" circuit at repeating point R^1, thus keeping the armature lever of sounder S down, and the "up" circuit intact. Again, on "up" closing the circuit, the sounder S^1 will restore the "down" circuit at point R^1 before diverting local X L^1 from sounder S, and by this means forming the local circuit L through sounder S before the local battery X L^1 is diverted through armature lever of S^1. Now suppose "down" wishes to stop "up" when he is sending: he merely breaks the circuit, and the first time "up" closes his circuit in sending, he finds it broken by the point R, the result of the "down" break.



The action of the repeating points in the above arrangement is to make the dots and dashes longer or firmer, by making contact before the sounders, and breaking later.

The electro-magnets M, M^1, may be double wound instead of the sounders, if thought preferable.

IT is stated in America that a company of English merchants have offered Mr. Edison £60,000 if he can successfully apply his aërophone or talking fog-horn to "the local telegraph wires" in London.

ON THE ACTION OF SONOROUS VIBRATIONS IN VARYING THE FORCE OF AN ELECTRIC CURRENT.*

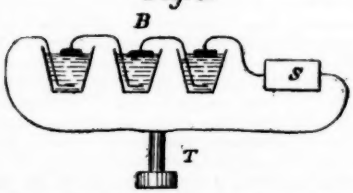
By Professor D. E. HUGHES.

THE introduction of the telephone has tended to develope our knowledge of acoustics with great rapidity. It offers to us an instrument of great delicacy for further research into the mysteries of acoustic phenomena. It detects the presence of currents of electricity that have hitherto only been suspected, and it shows variations in the strengths of currents which no other instrument has ever indicated.

It has led me to investigate the effect of sonorous vibrations upon the electrical behaviour of matter. Willoughby Smith has shown that the resistance of selenium is affected by light, and Börnstein has led us to believe that many other bodies are similarly affected. We know also that the resistance of all bodies is materially influenced by heat. Sir William Thomson and others have shown that the resistance to the passage of currents offered by wires is affected by their being placed under strains, and, inasmuch as the conveyance of sonorous vibrations induces rapid variations in the strains at different points of a wire, I believed that the wire would vary in its resistance when it was used to convey sound. To investigate this I made a rough-and-ready telephone, with a small bar magnet four inches long, half the coil of an ordinary electro-magnet, and a square piece of ferro-type iron, three inches square, clamped rigidly in front of one pole of the magnet between two pieces of board. When using the pendulum beats of a small French clock, or the voice, as a source of sound, I found this arrangement supplied me with an extremely delicate *phonoscope* or sound detector.

All the experiments detailed in this paper were made with the simplest possible means, and no apparatus of any kind constructed by a scientific instrument maker was employed. The battery was a simple Daniell's cell, of Minotto's form, made by using three common tumblers, a spiral piece of copper wire being placed at the bottom of each glass and covered with sulphate of copper, and the glass being then filled with well-moistened clay and water. A piece of zinc as the positive element was placed upon the clay. Iusulated wires were attached to each plate, and three of these cells were joined in series. All experiments were made on a closed circuit, the telephone being used as a phonoscope to detect variations in the current and the consequent reproduction of sound. The apparatus,

Fig. 1.



* Communicated by Prof. Huxley to the Royal Society. Received May 8, 1878.

or materials experimented upon, were used in the same way as the transmitter of the speaking telephone of Bell. The attached sketch will make this clear. B is the battery, S the source of sound or material examined, T the telephone or phonoscope.

I introduced into the circuit at S a strained conductor—a stretched wire—listening attentively with the telephone to detect any change that might occur when the wire was spoken to or set into transverse vibrations by being plucked aside. Gradually, till the wire broke, the strain was varied, but no effect whatever was remarked except at the moment when the wire broke. The effect was but momentary, but invariably at the moment of breaking a peculiar "rush" or sound was heard. I then sought to imitate the condition of the wire at the moment of rupture by replacing the broken ends and pressing them together with a constant and varying force by the application of weights. It was found that if the broken ends rested upon one another with a slight pressure of not more than one ounce to the square inch on the joints, sounds were distinctly reproduced although the effects were very imperfect.

It was soon found that it was not at all necessary to join two wires endwise together to reproduce sound, but that any portion of an electric conductor would do so even when fastened to a board or to a table, and no matter how complicated the structure upon this board, or the materials used as a conductor, provided one or more portions of the electrical conductor were separated and only brought into contact by a slight but constant pressure. Thus, if the ends of the wire terminate in two common nails laid side by side, and are separated from each other by a slight space, were electrically connected by laying a similar nail between them, sound could be reproduced. The effect was improved by building up the nails log-hut fashion, into a square configuration, using ten or twenty nails. A piece of steel watch chain acted well. Up to this point the sound or grosser vibrations were alone produced, the finer inflections were missing, or, in other words, the *timbre* of the voice was wanting, but in the following experiments the *timbre* became more and more perfect until it reached a perfection leaving nothing to be desired. I found that a metallic powder such as the white powder—a mixture of zinc and tin—sold in commerce as "white bronze," and fine metallic filings, introduced at the points of contact, greatly added to the perfection of the result.

At this point articulate speech became clearly and distinctly reproduced, together with its *timbre*, and I found that all that now remained was to discover the best material and form to give to this arrangement its maximum effect. Although I tried all forms of pressure and modes of contact, a lever, a spring; pressure in a glass tube sealed up while under the influence of strain, so as to maintain the pressure constant, all gave similar and invariable results, but the results varied with the materials used. All metals, however, could be made to produce identical results, provided the division of the metal was small enough, and that the material used does not oxidise by contact with the air filtering through the mass. Thus platinum and mercury are very excellent and unvarying in their results, whilst lead soon becomes of such high resistance, through oxidisation upon the surface, as to be of little or no use. A mass of bright round shot is peculiarly

sensitive to sound whilst clean, but as the shot soon become coated with oxide this sensitiveness ceases. Carbon again, from its surface being entirely free from oxidation, is excellent, but the best results I have been able to obtain at present have been from mercury in a finely divided state. I took a comparatively porous non-conductor, such as the willow charcoal used by artists for sketching, heating it gradually to a white heat and then suddenly plunging it in mercury. The vacua in the pores, caused by the sudden cooling, become filled with innumerable minute globules of mercury, thus, as it were, holding the mercury in a fine state of division. I have also tried carbon treated in a similar manner with and without platinum deposited upon it from the chloride of platinum. I have also found similar effects from the willow charcoal heated in an iron vessel to a white heat, and containing a free portion of tin, zinc, or other easily vaporised metal. Under such conditions the willow carbon will be found to be metallized, having the metal distributed throughout its pores in a fine state of division. Iron also seems to enter the pores if heated to a white heat without being chemically combined with the carbon as in graphite, and, indeed, some of the best results have been obtained from willow charcoal containing iron in a fine state of division.

Pine charcoal treated in this manner (although a non-conductor as a simple charcoal) has high conductive powers, due to the iron; and from the minute division of the iron in the pores, is a most excellent material for the purpose.

Any one of these preparations confined in a glass tube or a box, and provided with wires for insertion in a circuit, I call a "transmitter."

Reis, in 1860, showed how, by the movement of a diaphragm, intermittent voltaic currents could be transmitted, agreeing in exact number with the sonorous waves impinging on the diaphragm, and thus reproducing music at a distance by causing an electro-magnet to vibrate in unison with the diaphragm; and, with an iron diaphragm, Graham Bell showed how the vibrations of that diaphragm in front of a polarized electro-magnet could similarly induce magneto-currents, corresponding in number, amplitude, and form, with the sonorous vibration, and thus reproduce all the delicacies of the human voice. Edison and others have produced variations in the strengths of a constant current by causing the diaphragm to press directly upon some elastic conductor, such as carbon, spongy platinum, &c., the varying pressure upon these materials varying the resistance of the circuit, and consequently the strength of current flowing. Graham Bell and others have produced the same effect, by causing the vibrations of the diaphragm to vary the electro-motive force in the circuit. It will be seen, however, that in the experiments made by myself, the diaphragm has been altogether discarded, resting as it does upon the changes produced by molecular action, and that the variations in the strengths of the currents flowing are produced simply and solely by the direct effect of the sonorous vibrations.

I have found that any sound, however feeble, produces vibrations which can be taken up by the matter interposed in the electrical circuit. Sounds absolutely inaudible to the human ear affect the resistance of the conductors described above. In practice, the effect is so sensitive, that a slight touch on the board, by the finger nail, on which the transmitter is placed, or a mere touch with the soft part of a feather, would be distinctly heard at the receiving station. The movement of the softest camel hair brush on any part of the board is distinctly audible. If held in the hand, several feet from a piano, the whole chords—the highest as well as the lowest—can be distinctly heard at a distance. If one person sings a song, the distant station, provided with a similar transmitter, can sing and speak at the same time, and the sounds will be received loud enough for the person singing to follow the second speech or song sent from the distant end.

Acting on these facts, I have also devised an instrument suitable for magnifying weak sounds, which I call a *microphone*. The microphone, in its present form, consists simply of a lozenge-shaped piece of gas carbon, one inch long, quarter inch wide at its centre, and one-eighth of an inch in thickness. The lower pointed end rests as a pivot upon a small block of similar carbon; the upper end, being made round, plays free in a hole in a small carbon-block, similar to that at the lower end. The lozenge stands vertically upon its lower support. The whole of the gas carbon is tempered in mercury, in the way previously described, though this is not absolutely necessary. The form of the lozenge-shaped carbon is not of importance, provided the weight of this upright contact piece is only just sufficient to make a feeble contact by its own weight. Carbon is used in preference to any other material, as its surface does not oxidise. A platinum surface in a finely-divided state is equal, if not superior, to the mercurised carbon, but more difficult and costly to construct. I have also made very sensitive ones entirely of iron.

The best form and materials for this instrument, however, have not yet been fully experimented on. Still, in its present shape, it is capable of detecting very faint sounds made in its presence. If a pin, for instance, be laid upon or taken off a table, a distinct sound is emitted, or, if a fly be confined under a table-glass, we can hear the fly walking, with a peculiar tramp of its own. The beating of a pulse, the tick of a watch, the tramp of a fly, can thus be heard at least a hundred miles distant from the source of sound. In fact, when further developed by study, we may fairly look for it to do for us, with regard to faint sounds, what the microscope does with matter too small for human vision.

It is quite evident that these effects are due to a difference of pressure at the different points of contact, and that they are dependent for the perfection of action upon the number of these points of contact. Moreover, they are not dependent upon any apparent difference in the bodies in contact, but the same body in a state of minute subdivision is equally effective. Electrical resistance is a function of the mass of the conductor, but sonorous conduction is a function of the molecules of matter. How is it therefore that a sonorous wave can so affect the mass of a conductor as to influence its electrical resistance? If we assume a line of molecules, we know that a sonorous wave is accompanied by alternate compressions and rarefactions. If we isolate the part under compression from the part under dilation we vary the dimensions of the mass, and we alter its electrical resistance. In any homogenous conductor of finite dimensions the effect of

the one will exactly compensate for the effect of the other, and we get no variation of current; but if we break up this homogeneous conductor into a series of minute subdivisions without actually breaking their electrical continuity we destroy this neutralising influence, and we render evident the effect of sonorous vibrations in varying the dimensions of the mass of the conductor, and therefore in varying its electrical resistance, for we reduce the length of a portion of the conductor to a fraction of the length of a sonorous wave. Molecular action alone explains to me all the effects produced. Size or shape does not affect them. A piece of willow charcoal, the size of a pin's head, is quite sufficient to reproduce articulate speech. I regard the action as follows:—If we have two separate conductors joined simply by contact this contact offers a certain resistance. Now we can vary or lessen the resistance by increasing the pressure, thus bringing more points in contact or closer proximity. Now, as I employ a constant pressure on the contact, which is exactly under the same influence of the vibrations as the points of contact, more points or closer proximity can only be obtained through the molecular swelling or movement of the contact points.

If we assume a line of molecules at the point of contact of the minute masses of conducting matter in their neutral condition to be arranged thus:—

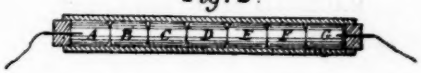
Fig. 3.

they will appear under compression as in second line of fig. 3, and under dilatation, as in third line of fig. 3.

In the former case the electrical resistance would be *less*, and in the latter case *more* than in the normal condition. Hence we should get variation in their electrical resistance, and thus sonorous waves could vary the strength of an electric current, and the variations of the electric current can be made to reproduce sonorous vibrations. These, however, would only produce the result in a certain line, say horizontal; but those perpendicular, while producing the same result, would be a half vibration behind, and thus if two contacts, the one horizontal and the other perpendicular, were on the same piece of charcoal and the conducting line joined to both, we should have interference. The contrary takes place as the more contacts we have, and the more varied their direction on the same the louder and purer the sound becomes. Hence there is no interference, and consequently the whole mass must swell and diminish equally in all directions at the same instant of time.

The tube transmitter, which I exhibit this evening, consists of an exterior glass tube two inches long and one quarter of an inch in diameter. In it are separate pieces of willow charcoal, each one quarter of an inch long and two terminals of the same material. The terminals are fastened in the tube, and connect exteriorly with the line and interiorly with the four loose pieces, thus:—

Fig. 2.



Here A is made to press on B, C, D, E, F, and G, until the resistance offered to the electrical current is about one-third that of the line upon which it is to be employed. It may be attached to a resonant board by the ends A or G. If the result was simply due to vibrations, we should have A and B making greater contact at a different time from F and G, and consequent interference. If it was a simple shaking or moving of B, C, D, E, and F, it could produce no change, as if B pressed more strongly on C, it would be less on A, and also if the tube was attached by the centre we should have no effect; but if the effect is due to a swelling or enlargement of B, C, D, E, F, it would make no difference where it is attached to the resonant board, as is actually the case. Again reduce the pressure of A upon B, &c., until they are not in contact, and no trace of current can be perceived by shaking the tube. The instant the sonorous vibrations pass in the tube there is electric contact to a remarkable degree, which could only have taken place by the molecules enlarging their sphere under the influence of the sonorous vibrations.

It is impossible to say what can be the applications or the effects of the discovery which I have had the honour of bringing before the Royal Society, for the whole question has been studied with crude materials, and scarcely sufficient time has elapsed to enable me to consider its ultimate uses. I do not desire to assert that there is anything in what I have brought forward that is superior to or equal to other transmitters used for telephony. It is as loud and far more sensitive than any I have yet heard, and it may be increased by multiplication of transmitting contacts in quantity or intensity; the loudness is at present limited by the capability of the receiver. The materials at my disposal, and the arrangement of them, have not yet been sufficiently studied. I only wished to show that it is possible to transmit clear and intelligent articulate speech, and to render audible sounds which have hitherto been inaudible by the mere operation of sonorous vibrations upon the conducting power of matter.

My warmest thanks are due to Mr. W. H. Preece, electrician to the Post Office, for his appreciation of the importance of the facts I have stated, and for his kind counsel and aid in the preparation of this paper.

I do not intend to take out a patent, as the facts I have mentioned belong more to the domain of discovery than invention. No doubt inventors will ere long improve on the form and materials employed. I have already my reward in being allowed to submit my researches to the Royal Society.

THE German Patent Office received 6,424 applications for patents during the past year, a greater number than was applied for in any other country except the United States.

ON THE PHOTOMETRY OF THE MAGNETO ELECTRIC LIGHT.

By CAPTAIN W. DE W. ABNEY, R.E., F.R.S.

AT intervals during the last three years it has been my duty to ascertain the value of the illuminating power of different sources of light, which have been brought before Government for military purposes. As there is nothing secret in the results obtained, it seemed to me that I might communicate them to the Royal Society, and I have obtained permission so to do.

The primary object of the experiments was to ascertain the relation between the horse-power expended, the light produced, and the number of revolutions of the armature. The machine employed was of the Gramme form, and weighed somewhere about 17 cwt. It had three pairs of vertical coils, one of which was used for magnetisation. To work it, what is known as the steam sapper was employed. This is a road locomotive from the shops of Aveling and Porter, of Rochester, and is adapted to driving machinery by applying a band to the fly-wheel. It works fairly steadily when not overtaxed. An indicator was attached for taking diagrams from which to calculate the horse-power expended. The number of revolutions of the armature was taken by a velocimeter, and a large tangent galvanometer was inserted in the circuit, the diameter of the arc being 33 times that of the needle. An automatically working electric lamp having perfectly dry square carbons of ½ inch side was the source of light, and was placed at fixed distances of 75, 150, or 50 feet from the measuring apparatus as circumstances required. It gave a steady light when the engine worked regularly, and the brilliancy of the light was not increased by altering the distance apart of the carbons. When a series of readings was to be taken, the horse-power expended in driving the machine with the collecting brushes up was found, and then the brushes turned down, and the light allowed to burn for ten minutes before any measurement was taken. The number of revolutions of the armature was then approximately ascertained, and a diagram taken when the velocimeter was applied to the machine. The readings of the galvanometer were recorded by an assistant working under my colleague, Captain Armstrong, R.E., and the measurements of the illuminating power taken by myself and checked by an intelligent assistant.

To secure the separation of the different portions of the spectrum, resort was had to absorbing media. After many trials I came to the conclusion that nothing seemed preferable to red glass, which absorbed practically every part of the spectrum except the red end, and an ammoniacal solution of copper sulphate. These two absorbing media were employed in the experiments; very little of spectrum is left unaccounted for, and the results obtained are sufficiently striking to record.

A red glass was obtained which had sufficiently plane surfaces, and a cell with parallel sides was used for holding the copper solution. The absorbing media were placed between the rod and the opaque screen, and absolutely parallel with the latter. The light transmitted through the red medium was first measured, and then through the blue. If the first and last of the readings compared favourably with each other, the series was taken as worthy of confidence. If, on the other hand, great fluctuations were observed, which was sometimes the case owing to the occasional irregularities of the motive power, and to impurities in the carbons themselves, a fresh set of readings was taken. As often as possible readings were taken through the blue and red media at the same number of revolutions per minute of the armature. This was not always practicable or even necessary. This will explain the reason of the variable revolutions recorded in the tables. I may remark that the revolutions were always taken at the commencement and end of each set of readings, and if these were tolerably close the mean was taken as the correct value for the mean of the readings. With any great variation, say of more than ten revolutions, the readings were rejected altogether. It was found difficult to make a comparison with a standard or pair of standard candles, owing to the small distance from the screen they sometimes occupied; hence an intermediate light from a paraffin lamp was made use of, which before and after each series of readings was compared with the standard candle. The variation of the lamp light was very small, ranging from 10·23 to 10·05. The light from the electric lamp was admitted into the observing-room through an aperture in the wall of about 18 inches square, and great care was taken that any reflected light was cut off the screen.

In addition to the optical readings, an endeavour was made to secure a record of the actinic value of light. Paper sensitised with silver chloride was exposed to the light at a distance of three feet from the carbon points, one strip was placed behind a cell filled with quinine sulphate, whilst another was exposed to the full action of the unshaded light. The times of exposure varied between one and ten minutes. The intensity of the actinism was measured by Roscoe's method, which need not be described. The curve obtained from the paper exposed behind the quinine cell is practically identical with that obtained optically from the blue components when any one point in the former curve is made to correspond to a point in the latter which has the same abscissa. The following tables give the results of the experiments. The horse-power given is the total horse-power recorded less that required to drive the machine with the brushes up.

Expenditure of H.-P.

Revolutions.	H.-P.
240	1·0
308	1·6
350	2·5
400	3·8
460	5·6
480	5·7
520	7·9
550	8·5
565	9·0

Integration of Blue Light.

Revolutions.	Candles.
240	369
308	660
350	750
425	1,700
460	2,500
490	3,000
520	4,860
550	4,800
565	6,500
580	6,000
600	10,100

Integration of Red Light.

Revolutions.	Candles.
240	180
308	280
460	860
500	1,080
520	1,300
540	1,620
575	1,520
580	2,100
600	2,400

Integration of Actinic Power.

Revolutions.	Candles.
350	890
460	2,750
560	9,000
580	10,050
600	11,020

Currents. Machine No. I.

Revolutions.	Tangents.	Remarks.
300	1·15	1st set of experiments.
350	1·31	
460	1·80	
540	2·47	
200	·51	Experiments during which the illuminating power was measured.
308	·90	
370	1·33	
425	1·48	
460	1·66	
500	1·96	
580	2·20	
600	2·30	

The following is a statement, furnished me by Captain R. Y. Armstrong, R.E., of the electrical conditions of the circuit.

The resistance of the stationary wire = 4·46 ohms.

" " magnetising coil = 0·44 ohm.

In the generator the resistance of the light circuit coil = 0·24 ohm.

The light coils were in divided circuit, as were also the right and left stationary coils.

When driven at from 375 to 383 revolutions, the resistance of the voltaic arc was about 0·18 ohm; the other resistances in the circuit were 0·7 ohm. The electro-motive force of the machine when driven at the above speed was 111 volts, a measure which has been arrived at by Captain Armstrong from other experiments. The electro-motive force between 375 and 383 revolutions of the armature was assumed to vary as the number of revolutions, an assumption which was borne out as practically correct by other measurements made for the purpose. In order to ascertain what effect the insertion of resistance had on the current, the following experiment was undertaken by Captain Armstrong with a smaller form of Gramme machine, called Machine No. II. Two resistances were inserted in the circuit for two different sets of readings, in the first case 1·1 ohm of total resistance, in the other 2·72.

The following table refers to these experiments :—

Currents. Machine No. II.

Revolutions.	Tangents.	Remarks.
398	1·40	1st set of experiments.
490	1·88	
846	3·08	
264	·10	
280	·12	
288	·17	
384	·38	
438	·48	
458	·53	2nd set of experiments.
484	·56	
534	·67	
692	·92	
842	1·25	
862	1·33	
1,014	1·45	

It will be noticed that practically the electro-motive force increases directly as the number of revolutions of the armature, a result which might have been expected theoretically. It will also be seen that the current for any given number of revolutions varies inversely as the resistance in circuit, or, in other words, that the electro-motive force for a given number of revolutions is constant.

In any results, therefore, which are given descriptive of the light produced by any machine, the following should be noted :—

Number of revolutions of armature ;
Resistance in circuit ;
Horse-power expended ;
Colour of light measured ;
Electro-motive forces

together with the size of the carbons employed, and other obvious details.—*Proceedings of the Royal Society.*

THE PROPAGATION OF ELECTRICITY IN CONDUCTORS.

By M. MASCART.

ACCORDING to the theory of Ohm, the differential equations which govern the propagation of electricity in conductors are identical with those which Fourier has established for the conduction of heat. The general integral of Fourier's equation is known under several forms, but the consideration of limited values sometimes renders the numerical applications difficult; we can, on the contrary, choose conditions which lead to a more simple solution, which in reality is applicable to the majority of observed phenomena.

Let us suppose that a cylindrical wire of indefinite length, primitively in a neutral state, has one end raised to a constant potential v_1. The wire will electrify itself progressively, and the potential v at one point is a function of the time t, and the distance x from the point considered at the electrified end. If we neglect the loss of electricity which takes place by the insulator, as well as the phenomena of induction, this potential satisfies the equation.

$$(1.) \qquad \frac{d^2v}{dx^2} = \frac{y}{cs} \qquad \frac{dv}{dt} = a^2 \frac{dv}{dt}$$

in which y means the electric capacity of unit length of the wire, c the co-efficient of conductivity, and s, the sectional area.

For a second wire placed in the same conditions as the first, and having its nature defined by another co-efficient a', we have similarly,—

$$(2.) \qquad \frac{d^2v'}{dx'^2} = a'^2 \frac{dv'}{dt'};$$

put $x' = mx$, $t' = nt$, m and n being constants, and consider v' as a function of x and t, the equation (2) then becomes

$$\frac{d^2v'}{dx^2} = \frac{x'^2 m^2}{n} \quad \frac{dv'}{dt}$$

If we choose the co-efficients m and n so as to get

$$a^2 = \frac{a'^2 m^2}{n}$$

that is to say,

$$\frac{a^2 x^2}{t} = \frac{a'^2 x'^2}{t'},$$

the potentials v and v' satisfy the same differential equation and the same limited conditions; they represent, therefore, the same function of x and t.

Thus, when we consider indefinitely long wires, which in practice are equivalent to wires long enough for the duration and propagation to have a sensible value, the potential v only changes when the ratio $\frac{a^2 x^2}{t}$ preserves the same value; it is then a function of this ratio. It follows from this that the time necessary for a distance x to produce a given potential, or more exactly a determinate fraction of the initial potential, is proportional to the square of the distance and to the co-efficient a^2 which characterises the wire.

In these conditions equation (1) only involves in reality an independent variable, and if we put

$$v = \left(\frac{ax}{2\sqrt{t}}\right) = f(y)$$

it becomes

$$\frac{d^2v}{dy^2} + 2y \frac{dv}{dy} = 0$$

which easily gives

$$v = c \int_0^y e^{-y^2} dy + c'$$

The constants c and c' will be determined by the limiting conditions; for $t = 0$ or $y = \infty$, we have $v = 0$; for $t = \infty$ or $y = 0$, we have $v = v_1$. It follows, therefore, that

$$\int_0^\infty e^{-y^2} dy = \frac{\sqrt{\pi}}{2}$$

$$(4) \qquad v = v_1 \left(1 - \frac{2}{\sqrt{\pi}} \int_0^y e^{-y^2} dy\right)$$

The integral which involves this formula cannot be simply expressed, but it can be obtained from tables.

Suppose now that the potential v, be maintained at the end of the wire only during a time τ, and that that point is afterwards put to earth. The potential at another point will be determined by the superposition of two states, the first being due to the permanent potential v_1, set up at the beginning of the time, the second to the permanent potential $-v_1$, established only at the epoch τ. The value of v relative to each of the states being a function of the time passed since the beginning of the resultant potential u at the same point will be

$$u = v(t) - v(t - \tau)$$

and if the time τ is infinitely small

$$u = \tau \frac{dv}{dt} = \tau \frac{dv}{dy} \frac{dy}{dt}$$

we deduce from it

$$(5) \qquad u = \tau \frac{v}{\sqrt{\pi}} \frac{y}{t} e^{-y^2} = \tau \frac{v_1}{\sqrt{\pi}} \frac{1}{t^{\frac{3}{2}}} e^{-\frac{a^2 x^2}{4t}}$$

This expression has been given by Sir William Thomson; we see that the value is only a simple function of the ratio $\frac{a^2 x^2}{t}$

The instantaneous contact of the end of the wire with one of the poles of a pile gives place, as we see by the value of u, to a species of electric shadow which propagates itself after a law quite complex, and which *s'etale* in proportion as it is propagated. The epoch τ at which the maximum of the potential takes place at a point is determined by the condition

$$\frac{du}{dt} = 0$$

which gives

$$\tau = \frac{a^2 x^2}{6} = \frac{1}{6} \frac{y}{cs} x^2.$$

This time τ may be considered as expressing the duration of propagation of an electric wave; it is proportional to the square of the distance, and is here expressed in absolute values in function of the electric constants of the thread.

We determine similarly, by calculation or by a geometrical construction, the wave which results from the successive contact of the wire with the positive and negative poles of the battery, during equal or unequal times and after different intervals. We can thus obtain by several successive contacts a wave much shorter than with a single contact, and this property is utilised in telegraphic signals.

The formulas (4), (5), and (6), represent exactly the phenomena which are produced in the ingenious experiments of M. Gaugain upon the propagation of electricity in bad conductors, such as threads of cotton and columns of oil.

If we put a point of the wire or its further extremity in contact with earth by a galvanometer of very high resistance, these formulas give also the intensity of the current derived at a point, the intensity of the current at the extremity of the wire, and the time necessary for the maximum to be attained, in both cases we can thus resolve, by sufficiently simple considerations, the most part of the problems relative to the propagation of telegraphic signals in submarine cables.

AN action in Chancery has been commenced by Mr. Morgan Brown against Mr. Ladd, to restrain the latter from making and selling telephones.

Notes.

A CURIOUS phenomenon has been observed on a property at Vernon, in France. Some five or six years ago, a garden planted with cherry-trees and gooseberry bushes was struck with lightning, a deep hole, about 10 centimetres in diameter, being made in the ground. Subsequently, everything died about the hole, the death circle becoming larger every year. It is now stated to be 7 metres in diameter, and has just reached a cherry-tree planted twelve years' ago, whilst some replanted gooseberry-bushes died in two years. The part the lightning has played in producing the phenomenon has not as yet been explained.

THE Friday evening lecture at the Royal Institution, on May 10th, was delivered by Sir William Thomson. Dr. Siemens being in the chair. The subject of the discourse was "The effects of stress on the Magnetisation of Iron, Cobalt, and Nickel." There was no elaborate preparation of lime light effects to dazzle the vulgar sense, no straining after startling paradoxes. The experiments were few and simple, and the language quite spontaneous; yet the lecture was illuminated by those splendid flashes of intelligence, which seem as natural to great and veritable genius as the scintillations are to the stars. Sir William first pointed out that certain magnetic bodies possessed the power of retaining magnetism in a greater degree than others, iron possessing this force in a high and nickel and cobalt in a lesser degree; para-magnetic bodies do not possess this power. The magnetic property in bodies might be different in different directions, that is it varied according to the structure of the body. Some bodies could be isotropic, that is, their magnetic properties might be the same in all parts of their mass; thus a lump of dough, when uniformly kneaded and placed between the poles of a powerful magnet, was unaffected; but when compressed in one direction, became influenced by the magnetism. The influence of the magnetism of the earth on a bar of soft iron was next pointed out, the bar becoming magnetic when held in the line of the dipping-needle, the upper end of the bar always taking the same magnetism, even when the ends were reversed, after the bar had been held in one direction. One interesting experiment consisted in inverting a bar of iron, part of the weathercock of Oxford Cathedral, which had stood upright in the steeple for over 300 years, and had been carefully treasured by Faraday in the same position, with the same end up, ever since. It would have been a scientific sacrilege to have done so idly, but the object was to see whether, after three centuries of fixity in position, it had acquired a fixity of magnetisation. No one had a better right to perform the act than the philosopher to whom Faraday has handed on the lamp, and no one could have done it with more reverence. The result could not be predicted, and it was awaited with considerable interest. Before inversion, the upper end of the bar was a true north-pole by virtue of its position, and the lower end a true south-pole. After inversion, the latter became a true north-pole, and the former upper end a true south-pole, showing that the magnetic induction of 300 years had not taken a permanent hold upon the iron. The effect of striking a bar of iron, cobalt, or nickel, held in the line of the dipping-needle, was shown to give a very perceptable amount of magnetism to them, even when the blows were very slight. It was pointed out that this effect was very much more considerable in long than in short bars, and that therefore it was advisable to avoid the use of such bars, long in proportion to their breadth, for stanchions in ships, as compass errors might become considerable from the magnetism which such bars might acquire. Villari's discovery was next alluded to, viz., that the effect of stretching a magnetised wire was to increase its magnetism, this increase reaching a maximum at a certain point and then decreasing as the strain was still further increased. On the relaxation of the strain, the magnetic condition of the wire was nearly but not quite restored to its normal power. Sir William had extended these experiments by determining the effect of transverse strains such as is produced by applying hydraulic pressure in an iron tube; this transverse strain was found to *de*crease the magnetic force in the tube when the magnetic power was feeble, a maximum being reached at a certain strain; when the magnetism was strong the opposite effect was produced, a transverse strain producing an *in*creased effect, rising to a maximum at a certain strain. The effect of torsion on a wire was found to be to decrease the magnetic power in a wire, no matter which way the twist was made; but on the relaxation of the twist, the magnetic power remaining in the wire was less than it was at first. In conclusion, Sir William said that the values of the discoveries did not necessarily lie in their immediate practical application, but in the fact that every new law brought to light added a link to the chain of human knowledge, and must be a gain to mankind. We hope, through the kindness of Sir William Thomson, to be able to give a more complete account of his interesting researches on the subject in our next issue.

TELEPHONIANA.—After the recent lamentable accident which happened near Hartford, Conn., U.S., to an excursion train returning from one of Moody and Sankey's revival meetings, over twenty Hartford physicians were promptly called to the scene of the disaster by means of private telephone wires centreing in a chemist's shop. For fire-alarms, and accidents of a serious kind, requiring prompt and collective assistance, the speaking telephone may yet prove invaluable.

ACCORDING to M. Demoget, of Nantes, a continuous humming sound is produced by a *trembler*, operated by a bundle of soft iron wire, introduced into a bobbin five centimetres long, wound with four layers of silk-covered copper wire, half a millimetre in diameter, through

which a current is made to pass. If a telephone deprived of its diaphragm and put in circuit with a line to the other end of which a second telephone is attached, be brought near this contrivance, the humming is heard in the second instrument. It is to be remarked that the maximum effect is obtained when the core of the exploring telephone is of soft iron, and the minimum when it is presented to the middle of the induction bobbin. In seeking to determine the range or field of the inductive action by finding the position of the first telephone, at which the sound ceased to be heard in the second telephone, it came out that the induction bobbin may be considered as a magnet, having at its middle a neutral line, and that it forms two inductive sections symetrically opposed. In the particular case in question, the inductive field was bounded by a double paraboloid, with its major axis 0·55 metres long in the prolongation of the magnetic bundle, and its greatest perpendicular diameter 60 centimetres. The sounds in the second telephone are audible when the telephone is near the ear. M. Demoget suggests the use of this arrangement in connection with the Morse key, to give short and long sounds, in preference to the Morse sounder.

IT is our pleasant duty to record another duplex success for Muirhead's Artificial Cable. The principal achievement for last year was the duplexing of the Aden to Bombay Cable; this year Muirhead's has just been successfully applied to the Direct United States Cable. It will be a little startling to electricians to hear that as many as fifty words a minute can now be transmitted through an Atlantic cable, twenty-five either way. While America has of late taken the lead in the invention of land-line apparatus, it is satisfactory to the profession in England to know that all the important advances of late years in submarine work, the siphon recorder, the curb-sender, the Muirhead duplex system, are due to Englishmen.

MESSRS. J. AND A. MUIRHEAD have also successfully duplexed the telegraph line between London and Enden, in Germany. This line is composed of a long land-line from London to Lowestoft and a cable to Enden, and this double character renders the problem of duplexing it somewhat complicated. The artificial line by which the difficulty has been overcome by Messrs. Muirhead consists of their artificial cable for the cable portion, and for the land-line portion a rheostat of silk-covered wire, rendered inductive by a spiral of fine metal foil wound over the silk. This wire has, we believe, been patented by them, and as its inductive capacity can be adjusted to that of the land-line it is desired to balance, it may make a better artificial line for duplexing land-lines than the ordinary resistance coils and condensers now in vogue.

THE Police-stations of Boston, U.S., have been fitted up with telephones.

IN the *Petit Journal* of Paris, for Nov. 22, 1865, is to be found the following passage on the Discovery of the Transmission of Sounds and Words by the Telegraph:—"A new discovery, which will produce immense results in its application to the arts and industries, has recently been added to the numerous wonders of this century: it is the transmission of the sounds of the voice by telegraph. The author of this invention is Signor Manzetti of Aosta, who is also the inventor of a celebrated automaton. He transmits words with the ordinary telegraph wire, and with an apparatus more simple than that which at present serves for despatches. Henceforth, two merchants may communicate instantaneously their business affairs between London and Calcutta, informing each other of their speculations, agreements, &c. A number of successful experiments have been made, which confirm the practicality of this invention. It also transmits musical notes, &c., &c." It appears that many other journals have published notices of this apparatus, among others the *Diritto* of Rome, for July 10, 1865; the *Echo d'Italia* of New York, August 9, 1865; the *Italie* of Florence, August 10, 1865; the *Commerceo d'Italia* of Genoa, December 1, 1865; the *Verita* of Novari, January 4, 1866; the *Commercio di Genova*, January 6, 1866. Manzetti was a poor artizan, and no one took him in hand.

THE AËROPHONE.—Something ought to be done to Mr. Edison, and there is a growing conviction that it had better be done with a hemp rope. Mr. Edison has invented too many things, and almost without exception they are things of the most deleterious character. He has been addicted to electricity for many years, and it is not very long ago that he became notorious for having discovered a new force, though he has since kept it carefully concealed, either upon his person or elsewhere. Recently, he invented the phonograph, a machine that catches the lightest whisper of conversation and stores it up, so that at any future time it can be brought out, to the confusion of the original speaker. This machine will eventually destroy all confidence between man and man, and render more dangerous than ever woman's want of confidence in woman. . . . This country has long suffered from excessive talk. Had nine-tenths of our citizens, who have been born during the last fifty years, been absolutely dumb, the Republic would doubtless have preserved its pristine purity. It is the interminable talk of Congressmen and other leading citizens, that is the source of all our public woes. Talk is likewise the bane of private life. With dumb wives there would be no need of divorce courts, and with dumb husbands, home might become a blessed reality instead of a poetic dream. And yet, knowing full well that talk is a monster of such hideous meaning that to be hated needs only to be constantly heard, Mr. Edison has devised an instrument by which the range of conversation is extended from a few feet to four miles.—*New York Times*.

THE ROYAL SOCIETY SOIRÉE.—The Annual Soirée of the Royal Society was held at the society's rooms in Burlington House on the 1st inst. A large and distinguished company was present. Amongst the objects exhibited, those of an electrical nature came in for a fair share of notice. The Telephone Company exhibited various forms of apparatus; the "telephone harp," of Mr. F. A. Gower, being the most prominent instrument. This invention enables some of the sonorous properties of the telephone to be rendered perfectly audible to a large audience. The telephone being a most unsatisfactory instrument for audible demonstration to a large audience, the harp of Mr. Gower will prove very useful for keeping up the interest of lectures on the subject. Mr. Henry Edmunds exhibited his method of showing variations in the pitch of sonorous vibrations by means of a revolving vacuum tube; this apparatus was first exhibited at the Royal Institution on the occasion of Mr. Preece's lecture on the telephone at that place, and a short description of it was given by us in the account of that lecture. In the same room with the foregoing, Mr. Robert Sabine exhibited his discovery of the effect of light on selenium in generating an electro-motive force. In the smaller library Mr. Ladd exhibited a large Holtz electrical machine, and specimens of Byrne's pneumatic battery. Messrs. Siemens Bros., in the same room, exhibited one of their dynamo-electric machines capable of giving an electric light equal to 1,200 normal sperm candles; an electric lamp was also shown by the same firm. Amongst the other scientific apparatus, the "phonograph," shown in action by Mr. Stroh, and explained in a short lecture by Mr. W. H. Preece, naturally excited primary attention. The "Mechanical Chameleon," the invention of Mr. A. B. Kempe, excited much interest amongst the more scientific portion of the visitors. This ingenious apparatus, by mechanical means, enables all the graduations of tint of any two colours to be obtained and to be varied at will, the one tint dissolving gradually or suddenly into any other, or remaining stationary if required. Mr. Francis Galton, F.R.S., exhibited a curious optical instrument, by which portraits of different persons could be combined so as to form a new face possessing the characteristics of each individual portrait. Mr. Nathaniel Holmes showed in action his flashing light signal apparatus, in which a brilliant "flare" is produced by the action of water dropping on phosphuret of lime. Besides the foregoing, many other objects of considerable interest were exhibited, which want of space forbids us describing.

MR. ALFRED M. MAYER, in a paper to *Nature*, states that the profile of the impressions made on the tinfoil of the phonograph in speaking the word *bat* (this being the only word so far experimented with) bear a close resemblance to the contours of the flame of König when vibrated by the same compound sound.

TRAFFIC RECEIPTS.

Name of Co., with amount of issued capital, exclusive of preference and debenture stocks.	Anglo-American Co. £7,000,000.	Brazilian Sub. Co. £1,300,000.	Cuba Sub. Co. £160,000.	Direct Spanish Co. £116,379.	Direct U.S. Co. £1,102,420.	Eastern Co. £3,697,000.	Eastern Ex. Co. £1,997,500.	Gt. Northern Co. £1,500,000.	Indo-Euro. Co. £425,000.	Submarine Co. £338,225.	West Coast America Co. £300,000.	Western and Brazilian Co. £1,398,200	West India Co. £883,210.
	£	£	£	£	£	£	£	£	£	£	£	£	£
April, 1878 ...	42,520	10,361	3,100	746	10,000	32,210	21,753	16,946	... ...	9,543	2,125	9,511	*5,295
April, 1877 ...	18,980	11,539	4,703	981	6,390	39,861	23,068	16,151	... ...	11,324	2,362	10,295	7,729
†Total Inc. 1878	76,630	... ...	166	... ...	1,770	691	... ...	3,483	... ...	... ...	... ...	... ...	247
†Total Dec., 1878	... ...	74	... ...	245	... ...	... ...	1,260	... ...	... ...	1,055	2,203	2,409	... ...

* Estimated. † Compared with same period 1877.

(The figures in this Table are as accurate as it is in our power to make them, but we do not guarantee their correctness).

Patents.

1623. "Improvements in the means and apparatus for kindling and extinguishing, or reducing lights by electricity for signalling and other purposes."—J. PINTSCH and J. SCHULKER, April 23.

1644. "Improvements in means for recording sounds, and in reproducing such sounds from such records."—T. A. EDISON, April 24.

1677. "An improved electrical signalling apparatus chiefly designed for use in ships."—G. ZANNI, April 25.

1756. "Improved electric apparatus for communicating between railway stations and trains, between trains, and between different parts of trains."—W. CLARK (commuicated by E. J. J. de Baillehache), May 1.

1779. "Improvements in speaking telephones, and in apparatus connected therewith."—J. F.BAILEY, (communicated by G. M. Phelps), May 2.

1783. "Electric and electro-pneumatic bell indicators."—J. W. EDMUNDSON, May 3.

ABSTRACT OF SPECIFICATIONS.

2982. "Electric lamps."—EMILE RAYNIER, Paris. Dated August 3, 1877. 8d. This consists in a regulator for the carbon points, and has been fully described in the TELEGRAPHIC JOURNAL for Feb. 1st, 1878.

2997. "Galvanic batteries."—J. and S. J. COXETER. Dated August 7, 1877. 4d. This consists of a manganese-zinc battery for medical purposes, contained in a vessel of waterproof fabric. The manganese and carbon is powdered, the positive pole being of platinum or a platinised surface.

3034. "Electric signalling apparatus on railways."—C. LECOQ, France. Dated August 9, 1877. 2d. This consists in a plan (undetailed) for working a semaphore and lamp signal by electro-magnetism. *(Not proceeded with.)*

3050. "Receiving instruments and relays."—W. H. PAGET HIGGS. Dated August 10, 1877. 6d. This designs to utilise the lessening of friction by the passage of an electric current, for the purpose of receiving relays. One method consists in providing a continuously revolving disc of paper, or other suitable absorbent substance, moistened with water or a saline solution. On the moistened disc is placed a metal disc which is kept from revolving by a torsional or elastic force. The two discs are connected in circuit with the line. When the current passes, the usual friction between them is reduced, and the metallic disc consequently turns in a direction opposite to the rotation of the paper disc. An arm or tongue attached to the metallic disc is thus moved to and fro in obedience to the signal currents, and makes or breaks contact, or produces visible signals.

3139. "Receiving instruments of electric telegraphs."—J. and A. MUIRHEAD. Dated August 17, 1877. 6d. This consists of a recorder, in which a rectangular coil of wire is made to rock to and fro between the poles of a magnet when the signal currents from the line are made to traverse it. The coil is suspended by two spiral springs coiled in opposite directions, and rigidly attached at their inner ends to the top and bottom of the coil, the whole being sustained by a single fibre at the top. A siphon, dipping in ink, is used as the marker. The ink is stimulated to flow by the discharges from a Ruhmkorff coil.

3161. "Apparatus for steering ships."—JEAN CASELLI, Florence. Dated August 20, 1877. 8d. The object of this invention is to put the rudder of a ship under the control of the captain directly, without the intervention of a helmsman. It is effected by means of a special suction and force pump, hydraulic presses, an auto-directive compass, an indicator of the rudder movements, an auto-motive marine telescope, and an automatic electric manipulator. By this arrangement, the deviation of the compass from the proper course can be made to work the rudder and guide the ship.

3187. "Magneto-dynamo electric machine."—PAUL JABLOCHKOFF, Paris. Dated August 22. 6d. The principal feature of this machine consists in making the armature consist of two soft iron discs, or mounted on an iron axis, with the coil between, so that the core takes the form of two iron cheeks, connected by the bar of the axle. These cheeks are caused to revolve, and the coil remains stationary or revolves with them. The cheeks are magnetised by external magnets inductively, so that each cheek is polar at its centre and circumference. To facilitate this inductive magnetisation, the periphery of each disc is formed into tooth-like projections which are attracted by the poles of the magnets. A tooth of one cheek is situated so as to come between two teeth of the other.

Correspondence.

To the Editor of THE TELEGRAPHIC JOURNAL.

DEAR SIR,—I have great pleasure in seeing an investigation of the interesting problem of determining the true copper resistance during earth currents, and in having given rise to Mr. Fujioka's critical examination of my geometric mean formula.

The resistance of the battery is of no *practical* consequence in this test, particularly when we employ one like the Leclanché's of small internal resistance, and the formula referred to (Messrs. Clark & Sabine, page 29) will *practically* give the same result whether the value *f* (the resistance of the battery) is inserted or not.

I should like Mr. Fujioka to understand that my geometric mean is an *empiric* formula, and that I do not and did not urge, that A E represents x, the true resistance of the line, but that I find *empirically* that A E, representing X, the mean proportional between r and R, is the true, *practically* the true expression for the resistance of the line A B.

I fully admit that my diagram only represents the potential curve in a small part of the bridge, and that the expression $\frac{2Rr}{r+R}$ is not equal to $\sqrt{rR}$ unless r and R are equal to one another. But whether $\frac{2rR}{r+R}$ is equal to $\sqrt{rR}$ is not the question. $\frac{2rR}{r+R}$ is a mathematically true expression when the resistance is taken *by deflection* reproduced through a known resistance, whereas in testing with *the Wheatstone bridge*, it never can hold good, except when there is no natural current flowing, *i.e.*, when $p = p'$ (figure 3), and $r = R$. $\sqrt{rR}$ is the constructed mean proportional between the resistances obtained in measuring with *the Wheatstone bridge*, *empirically* found to give the correct or about the correct value, whether strong natural currents are flowing or not.

In conclusion, I beg to remark that in all cases where the difference between the zinc and copper current reading is so great, that the *arithmetic mean is considerable*. I have had it 30 to 40 ohms *higher* than the

real resistance of the line. I find that *my geometric mean* ALWAYS *gives the true resistance within* TWO or THREE *ohms*, which, as every practical electrician will admit, must be considered a very satisfactory result.

Yours faithfully,

18, Prospect Terrace, Aberdeen, 8-5-78. CHRS. DRESING.

To the Editor of THE TELEGRAPHIC JOURNAL.

SIR,—In the course of some experiments lately with the Bell telephone, it occurred to me to try it instead of the galvanometer in laboratory and battery testing. The results were so satisfactory, that I now use both instruments indifferently.

From its simplicity, compactness, and portability, and its extreme delicacy withal, I feel satisfied the telephone will greatly supersede the galvanometer in laboratory experiments; and I have, therefore, great pleasure in drawing the attention of electricians to this, the last and not least useful application of the wonderful little instrument.

It can never, I fear, be employed in ordinary lime testing, on account of its great sensibility to earth and atmospheric currents.

J. J. FAHIE,
Memb. Soc. Tel. Engineers.

Teheran, Persia,
April 10, 1878.

[As our readers are aware, this application of the telephone was suggested and tried with success some time ago.—ED. TEL. JOUR.]

Proceedings of Societies.

SOCIETY OF TELEGRAPH ENGINEERS.

AT the ordinary general meeting of this Society, held at Great George Street, on the 10th ult., a paper was read by Mr. C. V. Walker, F.R.S., on "The unit of the Birmingham Wire Gauge." The paper purported to deal, not with the whole subject of gauges, but more especially with the graduations found by Mr. Walker on a particular gauge given to him in 1860 by Messrs. R. Johnson and Nephew.

After dwelling upon the chaos of existing gauges and the importance to telegraph engineers and others of a standard wire gauge, based upon some definite principle, the author said that a careful examination of the copy above referred to had led him to the conclusion that the unit of that particular copy of the B. W. G. was the $\frac{1}{80}$ of an inch. This unit, named by Mr. Walker the C. V. W. unit, was probably arrived at in the first instance by splitting up the inch into $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$, $\frac{1}{32}$, and $\frac{1}{640}$, and assigning values to intermediate sizes differing by multiples of $\frac{1}{16}$, $\frac{1}{32}$, $\frac{1}{64}$, or $\frac{1}{80}$. Table 1 gives the numbers complete of a gauge from $\frac{1}{2}$ inch or 320 C. V. W. units down to number 46, which comes to be one unit. The copy in Mr. Walker's possession was engraved only as far as number 30; the remaining numbers were run out suggestively by the author, by continuing the successive diminutions of one unit or $\frac{1}{2}$ unit. A reference to col. 3 will show that the successive diminutions of diameter are respectively as follows: 40, 20, 10, 8, 4, 2, 1, $\frac{1}{2}$, the transmitters taking place at numbers + .0, 4, 12, 17, 21, 25, and 33. It was claimed for this system of sub-division that if it was not *the* true standard of the B. W. G., it was, at least, one upon which *a* standard could be based, with values calculated upon a much more definite system than was to be found elsewhere. It has also the advantage of fixing the sizes of our more familiar wires, such as numbers 8 and 11, at what they are *approximately* known to be. Thus, number 11 is fixed at $\frac{1}{8}$ inch (·125), which is the size specified for it by the Postal Telegraph Department.

TABLE 1.

1. Nos.	2. Diameters.	3. C. V. W. Units.	1. Nos.	2. Diameters.	3. C. V. W. Units.
40	$\frac{1}{2}$	320	21		22
30	$\frac{1}{2}\frac{4}{0}$	280	22	$\frac{1}{3}\frac{1}{2}$	20
20	$\frac{3}{8}$	240	23		18
			24	$\frac{1}{4}\frac{1}{0}$	16
0	$\frac{1}{3}\frac{1}{2}$	220			
1	$\frac{7}{1}\frac{7}{6}$	200	25		15
2	$\frac{9}{3}\frac{9}{2}$	180	26	$\frac{7}{3}\frac{7}{2}\frac{7}{0}$	14
3	$\frac{1}{4}$	160	27		13
			28	$\frac{3}{1}\frac{3}{6}\frac{3}{0}$	12
4	$\frac{1}{6}\frac{5}{4}$	150	29		11
5	$\frac{1}{3}\frac{7}{2}$	140	30	$\frac{1}{8}\frac{1}{4}$	10
6	$\frac{1}{6}\frac{3}{4}$	130	31		9
7	$\frac{5}{1}\frac{5}{6}$	120	32		8
8	$\frac{1}{6}\frac{1}{4}$	110			
9	$\frac{9}{3}\frac{9}{2}$	100	33		7½
10	$\frac{9}{6}\frac{9}{4}$	90	34		7
11	$\frac{1}{8}$	80	35		6½
			36		6
12	$\frac{9}{8}\frac{9}{0}$	72	37		5½
13	$\frac{1}{1}\frac{1}{0}$	64	38		5
14	$\frac{7}{8}\frac{7}{0}$	56	39		4½
15	$\frac{5}{4}\frac{5}{0}$	48	40		4
16	$\frac{1}{1}\frac{1}{6}$	40	41		3½
17	$\frac{9}{1}\frac{9}{6}\frac{9}{0}$	36	42		3
18	$\frac{1}{2}\frac{1}{0}$	32	43		2½
19		28	44		2
20	$\frac{3}{8}\frac{3}{0}$	24	45		1½
			46		1

Mr. Latimer Clark, who has long been concerned at the confusion that reigns, took the question in hand some years ago, and presented a paper "On the Birmingham Wire Gauge," to the *British Association*, which was read at Dundee, in September, 1867; followed by another, read at Exeter, in August 1869.

In his former paper he speaks of the origin of the system, and its date being unknown; of there being no authorised standard in existence; and of a great number of gauges being in practical use, which differ from each other to a serious extent.

He has prepared a "Table of the sizes of the Birmingham Wire Gauge," as given by different authorities (thirteen in all), diameters in mils. or thousandths of an inch. If all other evidence were wanting, this table alone bears witness to the fact, put on record by Mr. Clark, that there is no authorised standard in existence.

A few illustrations of the sizes assigned by the several authorities to certain wires familiar to us have been extracted from Mr. Clark's tables, and reduced to C. V. W. units in Table 2. It will be seen that Warrington, Culley, and Rylands, 1862, are alike throughout; they are alike also in the complete table, and are doubtless derived from the same source, and may therefore be counted as one authority. There are no less than nine different sizes attributed to our No. 8, and not one of them correspond with the Johnson and Nephew's size, which is a trifle higher than any. No. 11 is more fortunate. The value assigned to it, one-eighth of an inch, is very consistent, and it has the majority of advocates. It comes out in a whole number, 80 C.V.W. units, or 125 mils. This is seen in col. 2 of Table 3, which is taken from p. 178 of *Preece and Sive-*

wright's Telegraphy published in 1876. Col. 3 gives the mils. of col. 2 in C.V.W. units. Col. 4 actual values in C. V. W. units to the respective wires, numbered in cols. 1 and 5.

TABLE 2.

Diameters in C. V. W. Units of Certain Selected Wires as given by various Authorities.

Authorities.	No. 6.	No. 8.	No. 11.	No. 14.	No. 18.	No. 22.	No. 35.	No. 40.
C. V. W. Unit	130	110	80	56	32	20	6½	4
L. C. . .	126·9	101·5	72·6	51·3	33·2	21·3	4·9	2·8
Warrington .	128	108·8	80	54·4	32	19·2		
Silvertown .	124·1	103						
Culley . .	128	108·8	80	54·4	32	19·2	5·0	2·1
Rylands, 1862	128	108·8	80	54·4	32	19·2		
Rylands, 1866	128	101·7	74·8	50·5	30	17·9		
Holtzapffel .	129·9	105·6	76·8	53·1	31·3	17·9	3·2	
Molesworth .	128	106	80	53·1	31·3	17·9	3·2	
Schaw, R.E. .	133·3	109·9	80	56	33·3	19·9		
Cocker . .	128	102	76·8	57·6	32	19·2	3·8	
Bartholomew .	133·7	107·8	80	54·4	33·9	19·2	3·5	
Whitworth .	128	105·6	76·8	54·4	32	17·9	3·2	
Hall . .					27·5	20·4	5·5	

With so many conflicting elements before him, which it was impossible to reconcile, Mr. Clark expressed in his paper a hope that the British Association might appoint a committee, and "issue a gauge under their authority, bearing the title of the British Association gauge, or British gauge." Failing this, he took the matter in hand himself. He was "inclined to think it probable that the original gauge may have been formed by taking as its basis No. 16 bell wire, having a diameter of $\frac{1}{16}$ of an inch, and that each succeeding size up to No. 1 was formed by successive additions of 25 per cent. to the weight. This would be equivalent to successive increments of 11·8034 per cent. to the diameters . . . . "

TABLE 3.

Preece and Sivewright's Diameters of Certain Wires.

(Telegraphy, p. 178.)

	Preece and Sivewright's Values.		C. V. W. Units.	
1	2	3	4	5
Nos.	In Mils.	In C. V. W. Units.		Nos.
4	240	153·6	150	4
5	220	140·8	140	5
6	200	128·0	130	6
7	180	115·2	120	7
8 G.P.O.	170	108·8	110	8G.P.O.
8	165	105·6	110	8
9	150	96·0	100	9
10	135	86·4	90	10
11 G.P.O.	125	80·0	80	11G.P.O.
11	120	76·8	80	11

Table 4 gives the proposed British gauge founded on these principles and suggested by Mr. Clark in his Dundee paper.

The gauges themselves, Mr. Walker remarked, are, indeed a fertile source of error.

This question has recently been taken up in America, and the *Journal of the Franklin Institute*, for February, 1878, contains a "Report on a Standard Wire Gauge," read before the American Institute of Mining Engineers, at the Autumn meeting, October, 1877, dwelling mainly upon the gauges themselves, which they say should be simple in construction, not readily worn, easy of adjustment, and not too expensive. Reference is made to (1) those like our ordinary gauge, made with slots, and the sides of which they state are not always parallel, as of course they should be; (2) those with holes, as the Whitworth wire gauge; (3) those of a V, cut in steel, or of two steel bars; (4) sliding calipers with verniers; (5) the micrometer screw-gauge; and they decide in favour of the latter, with the sizes to be expressed in thousandths of an inch (or mils.); elsewhere spoken of as fractions of an inch.

TABLE 4.

PROPOSED BRITISH GAUGE.

Areas increasing 25 *per cent. Diameters increasing* 11·8034 per cent.

Nos.	Areas in square inches.	Diameters in "Mils."	Nos.	Areas in square inches.	Diameters in "Mils."
00000	·2878182	605·3	19	·0016990	46·5
0000	·2302546	541·4	20	·0013591	41·6
000	·1842037	484·3	21	·0010873	37·2
00	·1473630	433·1	22	·0008699	33·3
0	·1178904	387·4	23	·0006959	29·7
1	·0943123	346·5	24	·0005567	26·6
2	·0754498	309·9	25	·0004454	23·8
3	·0603598	277·2	26	·0003563	21·3
4	·0482879	247·9	27	·0002851	19
5	·0386303	221·7	28	·0002280	17
6	·0309042	198·3	29	·0001824	15·2
7	·0247234	177·4	30	·0001459	13·6
8	·0197787	158·7	31	·0001167	12·2
9	·0158229	141·9	32	·0000934	10·9
10	·0126583	126·9	33	·0000747	9·7
11	·0101267	113·5	34	·0000597	8·7
12	·0081013	101·5	35	·0000478	7·8
13	·0064811	90·8	36	·0000382	6·9
14	·0051848	80·3	37	·0000306	6·2
15	·0041479	72·6	38	·0000245	5·6
16	·0033183	65	39	·0000196	5
17	·0026547	58·1	40	·0000157	4·5
18	·0021237	52			

They found, as we do, that gauges "not only differ according as they are made by different manufacturers, but in a package of a dozen, made by the same manufacturer, there were often very perceptible and annoying differences. . . . Neither the number nor the diameter is ordinarily correct, so that there is a double source of inaccuracy, as the number does not express the exact diameter, nor the diameter the number."

Mr. Walker, in concluding his paper, truly remarked that while we have the true time and the standard foot and yard and pound weight, open to all the world for reference on the outer walls of the Royal Observatory, Greenwich, it is almost absurd to say that we have no means of knowing for certain what the diameter of an article in such common use as No. 8 iron wire ought to be.

AT the ordinary general meeting, held on the 8th instant, a paper by Dr. Clarence Blake, of Boston, U.S., on "Sound, in Relation to the Telephone," was read by the secretary. Its classical nature precludes the possibility of rendering a mere summary of it intelligible without the accompanying illustrations, which

we have not space to reproduce here. We hope, however, to give some account of it when reporting the discussion, which is promised for the next meeting.

A second paper, "On the Telephone Harp," was read by Mr. F. A. Gower, also of Boston, the inventor of the instrument, and was elucidated by some interesting experimental illustrations. This "Harp," which formed an object of great interest at the recent *conversasione* of the Royal Society, may be briefly described as follows:—

A series of steel tongues, similar to those of a large musical box, are firmly clamped at their base by a double bed-plate of steel. On the upper side of each tongue, and near the base, is soldered a small platinum spring, which shares the motion of the tongue and vibrates against a metal contact-pin. The journey performed by the platinum spring being so much less than that of the extremity of the tongue, a much finer adjustment is thus rendered possible, while the resilience of the spring prevents the vibrations from being so quickly damped as they would be if the tongue ends made the contacts. Another and lighter series of metal tongues, or "switch" springs, is ranged over the contact pins. The key-board is similar to that of a piano; and two electrodes are led from the instrument —one connected with the whole series of steel tongues, the second with the "switch" tongues.

On striking a key two operations are performed; firstly, a hammer like that of a piano is jerked up against the steel tongue, falling again immediately so as to leave the latter vibrating; and, secondly, the last part of the depression of the key presses the "switch" spring on the contact pin. When therefore, the electrodes are joined to the poles of a battery, a series of currents flow through the circuit, one for each vibration of the tongue; and if a telephone is inserted in the circuit, the diaphragm gives out a loud musical note corresponding to proper note of the tongue.

In the experiments performed by Mr. Gower before the Society, two or more distinct circuits were employed; the first comprised the "Harp," the battery (2 to 4 cells, Leclanché or bichromate), and the primary wire of an induction coil; the second included the secondary wire of the coil, and the telephone on the lecture table. A number of airs, skilfully performed upon the "Harp" by Mr. Higgs, Mr. Gower's musical assistant, were vividly reproduced by the telephones on the table, and also by others placed in different parts of the theatre.

One experiment was especially interesting; and for this, four circuits were employed. The first included "Harp," battery, primary of induction coil, and the coils of a "relay" telephone, these being all placed in a distant room. The second remained as before. The "relay" telephone was provided with a contact point, adjustable by a screw, and against which its diaphragm vibrated. This contact point and the diaphragm formed with a second battery, and the primary of a second induction coil, the third circuit; and the fourth consisted of the secondary of the second induction coil, and a Geissler tube. Music being now played upon the "Harp," currents from the first battery flowed as before through the first circuit; induced currents flowed the second circuit, reproducing the music in the telephones; currents caused by the make and break of the relay telephone flowed through the third circuit; and induced currents, from the second induction coil, flowed through the fourth (vacuum tube). Each note was therefore accompanied by an illumination of the Geissler tube.

Some useful lessons, Mr. Gower remarked, are deducible from these experiments, and are not at first sight reconcilable with each other. Thus, on the one hand, placing the finger upon the diaphragm of one of the telephones from which music was proceeding had no apparent effect: the music went on as before, even when the diaphragm was tightly pressed. This appeared to show that the effective vibrations were principally molecular. On the other hand, the "relay" telephone showed that, when free, the diaphragm oscillated sufficiently to make and break contact with a battery terminal.

These and other experiments shown by Mr. Gower were watched with much interest, and elicited frequent applause.

General Science Columns.

JULIUS ROBERT MAYER, the illustrious physicist, was born at Heilbronn, in Würtemburg, on November 25th, 1814. His name will be ever memorable in conjunction with that of Dr. Joule, of Manchester, as the father of the science of thermo-dynamics. Mayer pursued his medical studies first at Munich, then at Paris, and, afterwards, in 1840, proceeded to Batavia, in the island of Java, where he had occasion to bleed a native suffering from fever. He was struck with the vivid redness of the venous blood, as compared with that of Europeans, and came to the conclusion that it was due to the warmer climate rendering oxidation of the blood less necessary to maintain the animal heat. It was this accident which directed his mind to its future sphere of labour. He was led thereby to study the phenomena of animal heat and the far-reaching relations of heat and work done. He returned to Germany and became "City physician" at Heilbronn, doing good small work for Heilbronn, and greater work for the world. In 1842 he published his first paper, "On the Forces of Inorganic Nature," in Leibig's *Annalen der Chemie*, and attempted to prove the two great principles of the indestructibility of matter and the conservation of energy. Mayer's method of proof has been questioned of late chiefly by Professor Tait; but it must be admitted that Mayer did the best he could with the materials and opportunities at his disposal. It was reserved for Joule, by his series of classical experiments, extending from 1843 to 1849, to place on a firm and practical foundation of quantitative results the new principle of the conservation of energy, and, to demonstrate what Mayer had been the first to enunciate. Other essays on cognate subjects followed each other from Mayer's pen at intervals of a few years, including one on "Celestial Dynamics," which created a great deal of notice. These essays were re-printed in one volume, entitled, *Die Mechanik der Wärme*, in 1867. In "Celestial Dynamics" he propounded the well-known theory that the heat of the sun is maintained by the impact of countless meteorites on its disc, and that the zodiacal light is but the reflection of the sunlight on this dust of the inter-stellar space. Domestic affliction and public criticism for a time overthrew his reason, and he was confined in a madhouse; but after a few years he recovered his usual health, and peacefully cultivated his garden at Heilbronn, where he died on March 21st.

PROFESSOR TYNDALL ON SOUND-PRODUCERS (*continued*).—I have referred more than once to the train of echoes which accompanied the explosion of gun-cotton in free air, speaking of them as similar in all respects to those which were described for the first time in my report on fog-signals, addressed to the Corporation of Trinity House in 1874.* To these echoes I attached a fundamental significance. There was no visible reflecting service from which they could come. On some days, with hardly a cloud in the air, and hardly a ripple on the sea, they reached us with magical intensity. As far as the sense of hearing could judge, they came from the body of the air in front of the great trumpet which produced them. The trumpet blasts were five seconds in duration, but long before the blast had ceased the echoes struck in, adding their strength to the primitive note of the trumpet. After the blast had ended the echoes continued, retreating further and further from the point of observation, and finally dying away at great atmospheric distances. The echoes were perfectly continuous as long as the sea was clear of ships, "tapering" by imperceptible gradations to absolute silence. But when a ship happened to throw itself athwart the course of the sound, the echo from the broadside of the vessel was returned as a shock which rudely interrupted the continuity of the dying atmospheric music.

These echoes have been ascribed to reflection from the crests of the sea-waves. But this hypothesis is negatived by the fact that the echoes were produced in great intensity and duration when no waves existed—when the sea, in fact, was of glassy smoothness. It has been also shown that the direction of the echoes depended not on that of the waves, real or assumed, but on the direction of the axis of the trumpet. Causing that axis to traverse an arc of 210°, and the trumpet to sound at various points of the arc, the echoes were always, at all events in calm weather, returned from that portion of the atmosphere towards which the trumpet was directed. They could not, under the circumstances, come from the glassy sea; while both their variation of direction, and their perfectly continuous fall into silence, are irreconcileable with the notion that they came from fixed objects on the land. They came from that portion of the atmosphere into which the trumpet poured its maximum sound, and fell in intensity as the direct sound penetrated to greater atmospheric distances.

To attempt to interpret an experiment which I have not had an opportunity of repeating, is an operation of some risk; and it is not without a consciousness of this that I refer here to a result announced by Professor Joseph Henry which he considers adverse to the notion of aërial echoes. He took the trouble to point the trumpet of a syren towards the zenith, and found that when the syren was sounded no echo was returned. Now the reflecting surfaces which give rise to these echoes are for the most part due to differences of temperature between sea and air. If, through any cause, the air above be chilled, we have descending streams—if the air below be warmed, we have ascending streams as the initial cause of atmospheric flocculence. A sound proceeding vertically does not cross the streams, nor impinge upon the reflecting surfaces, as does a sound proceeding horizontally across them. Aërial echoes, therefore, will not accompany the vertical sound as they accompany the horizontal one. Professor Henry's experiment, as I interpret it, is not opposed to the theory of aërial echoes which I have ventured to enunciate. But, as I have indicated, not only to see, but to vary such an experiment, is a necessary prelude to grasping its full significance.

In a paper published in the "Philosophical Transactions" for 1876, Professor Osborne Reynolds refers to these echoes in the following terms: "Without attempting to explain the reverberations and echoes which have been observed, I will merely call attention to the fact that in no case have I heard any attending the reports of the rockets, although they seem to have been invariable with the guns and pistols. These facts suggest that the echoes are in some way connected with the direction given to the sound. They are caused by the voice, trumpets, and the syren, all of which give direction to the sound; but I am not aware that they have ever been observed in the case of a sound which has no direction of greatest intensity."

The reference to the voice and other references cause me to think that, in speaking of echoes, Professor Osborne Reynolds and myself are dealing with different phenomena. Be that as it may, the foregoing observations render it perfectly certain that the condition as to direction here laid down has nothing to do with the production of the echoes.

There is not a feature, moreover, connected with the aërial echoes which cannot be brought out by experiments in the laboratory. Standing on the deck of our steamer in front of the trumpet, at the South Foreland, on a day of acoustic flocculence, the sound failed to penetrate to any considerable distance. The open air of a room may be thrown into a condition which shall act in a precisely similar manner. Standing behind the trumpets, the sound which was refused transmission was sent back by reflection. With the open laboratory air, rendered purposely non-homogeneous, precisely the same effect is obtained. I have recently made the following experiment:—A rectangle, 22 inches by 12, is crossed by 23 brass tubes, each having a slit along it from which gas can issue. In this way, 23 low, flat flames are obtained. A sounding reed, fixed in a short tube, is placed at one end of the rectangle, and a sensitive flame at some distance beyond the other end. When the reed sounds, the flame in front of it is violently agitated, and roars boisterously. Turning on the gas, and lighting it as it issues from the slits, the air above the flames become so heterogeneous that the sensitive flame is instantly

* See also *Philosophical Tranzactions* for 1874, p. 183.

stilled by the aërial reflection, rising from a height of 6 inches to a height of 18 inches. Here we have the acoustic opacity of the air in front of the South Foreland strikingly imitated. Turning off the gas, and removing the sensitive flame to some distance behind the reed, it burns there tranquilly, though the reed may be sounding. Again, lighting the gas as it issues from the brass tubes, the sound reflected from the heterogeneous air throws the sensitive flame into violent agitation. Here we have imitated the aërial echoes heard when standing behind the syren-trumpets at the South Foreland. The experiment is extremely simple, and in the highest degree impressive.

GASES DISSOLVED IN SEA-WATER.—Mr. J. Y. Buchanan, from observations made on board the *Challenger*, arrives at the conclusion that the absolute amount of oxygen and nitrogen contained in sea-water is less than that contained in river water; but the relative proportions of the two gases to each other is about the same in both kinds of water. He is also of opinion that the absolute amount of gas dissolved in sea-water depends on the temperature; and that water at a great depth has all the physical properties of surface water, although when brought to the surface from a great depth water parts with some of the gas contained in it, since small bubbles may be observed to cluster on the sides of the vessel holding it, if it be allowed to stand. Surface sea-water contains from 33 to 35 per cent. of its volume of oxygen, the former result being obtained from the region of the trade winds, the later from the Antartic circle. Up to depths of 1,800 feet the amount of oxygen decreases, and then increases. When the bottom is composed of diatomaceous mud or ooze, the superincumbent water contains most oxygen, and when of red-clay least oxygen. This fact seems to prove that its presence depends in some way on the prevalence of animal life.

DREDGING.—During his recent trip to the Gulf of Mexico, Professor Agasziz made use of a steel rope $1\frac{1}{2}$ inch in diameter, for dredging, and found it in point of celerity and convenience, beyond comparison with a hemp rope. Thus in dredging a well or sounding operations, steel is taking the place of hemp.

ANOTHER NEW EXPLOSIVE.—Professor Osborne Reynolds has discovered a new explosive, composed of seventy-five parts of chlorate of potassium to twenty-five parts of sulphurea. Sulphurea is a substance discovered by Professor Reynolds some years ago in the waste product of coal-gas. The two ingredients can be kept apart until required, and may therefore be safely transported. The new explosive is a white powder, which can be ignited at a lower temperature than gunpowder, and leaves less ash.

IMPROVEMENTS IN ELECTRIC GAS-LIGHTING.—The various appliances that are now so successfully employed in lighting gas-lamps in halls, theatres, and in the streets, usually aim only to furnish the spark or hot wire that will fire the gas. The supply of gas must be turned by hand or by some mechanical means, and thus a part of the work of gas-lighting must still be performed at a waste of time, labour, and gas. To obviate this, and to save the gas thrown away after it is turned on and before it is lighted, a new system of electric gas-lighting has been brought out that turns on the gas, and at the same time sets it on fire. The same apparatus will also shut off the gas and extinguish the light, and by attaching it to a clock it can be made to light and put out the lamps automatically at any hour at which the clock may be set. The apparatus consists of a small electro-magnet, designed to be placed on the gas-jet just over the gas-cock, and a vibrating armature, and platinum wire for lighting the gas. The gas cock is a two-way valve, and having a small ratchet wheel in the place of the usual handle. This wheel is placed on one side of the gas pipe, and the electro-magnet is put on the opposite side; between them is hung a rocking-bar, supported on pivots on the pipe; at one end of this bar is the armature of the magnet, and at the other end is a pawl, playing in the ratchet wheel; a spring is also added to give the bar a vibrating motion when the magnet is excited by the current from the line. When the circuit is made by the battery at the station, the rocking-bar vibrates, and by means of the pawl turns the wheel part way round, and thus lets on the gas. The same current that sets the bar in motion also inflames the gas at the same instant. The gas being turned on, an eccentric on the side of the well breaks the circuit, and the wheel stops, leaving the gas turned on. After all the lamps in the circuit have been lighted in turn, the circuit is broken, and everything remains as it is till it is again closed. This second closing of the circuit produces the same effect on each apparatus in turn, but with the reverse effect in the lamp, for the wheel is pulled round by the vibrating bar, and the gas is shut off and the lamps extinguished. This same arrangement may be attached to single lamps in the house by omitting the electro-magnet, and substituting a small chain, that may hang below the lamp. On pulling this chain by the hand the pawl plays in the ratchet-wheel and turns on the gas, and at the same time lifts the platinum wire into contact with the jet, and the resulting spark fires the gas. To shut off the gas the chain is pulled again, and in the same manner the wheel is carried part way round, and the gas is shut off. This apparatus is designed for lighting street lamps by a cable laid just under the pavement, and from lamp to lamp. Circuits of 200 street lamps may be turned on and lighted, and turned off in a few seconds from a central office or the police station, either by hand or by means of clock-work. By a simple arrangement the same cable may also be exposed at each lamp-post, so that the police on beat may communicate by telephone with the station.—*Scribner's Monthly*.

A CURIOUS COLUMN OF LIGHT.—At Logelbach, in Alsace, on March 23rd, just before sunrise at 7 a.m., a luminous column was seen, orange red, at the horizon, and fading into ashy red as it rose upward in the sky. Its height was from 25° to 35° of arc, and its breadth 2° to 2½°. It appeared to be based on the sun, which rose at 7 o'clock, of an indigo-red colour, and lifted the column with it. A few minutes later the column gradually disappeared from the top downwards.

City Notes.

Old Broad Street, May 14th, 1878.

IT is satisfactory to learn that the Brazilian Submarine Telegraph Company is now in smooth water again. On the 14th of last month their cable was broken close to the shore at Lisbon, through being hooked by the anchor of a ship. The chairman, very properly, took occasion, at the half-yearly meeting last week, to explain that the breakage was not owing, in any degree, to any defect in the cable; and though, thanks to the attention of the official of the Telegraph Construction and Maintenance Company, it was quickly and thoroughly repaired, the business of the concern was, of course, affected for a time. We are not sure, however, that the breakage was not a blessing in disguise: for we gather from Viscount Monck's speech of the other day that the receipts of the Company have increased by nearly £100 a day since the cable began working again, and £100 a day more means a large sum a year extra; so what will repairing the cable cost? Turning to quite another matter, the noble chairman told the shareholders at the meeting that the arrangement they made with the Western and Brazilian Company had been very unsatisfactory to the Company; we can readily understand that it has: for they had, he said, paid the Western Company very large sums of money, and received very little, if anything, in return. As we are also far from sanguine respecting the future of the Western and Brazilian Company, we agree with the intimation of Lord Monck that the arrangement should in the interest of the shareholders of the Brazilian Submarine Company be reconsidered at the earliest possible moment. A hint was given that the directors of the Western Company might not be willing to meet the directors of the Submarine Company in an amicable spirit; but, if the former are wise they will not run any risk of crippling their resources by expensive litigation. In any case, there is certainly no reason why the Brazilian Submarine Company should continue an arrangement which after a fair trial, has been found to be the reverse of advantageous to the shareholders. The report of the Brazilian Company was unanimously adopted.

At the seventh ordinary general meeting of the shareholders of the German Union Telegraph and Trust Company, a satisfactory report of the progress of the company was read and adopted without discussion. The total receipts for the year ending May 1st amounted to £12,293 7s. 6d., showing an increase over the previous year of £632 14s. 1d. The working expenses were £474, leaving a balance available for dividend of £11,759 7s. 2d. Most people will agree that after the amount of the working expenses had been mentioned there was no need for any discussion. A dividend of 6s. per share, making, with the *interim* dividend distributed in January, £5 17s. 6d. per cent. for the year, was agreed to and accordingly declared. The increase in the business of the company for the year, considering the smallness of the concern, is very great, the number of messages transmitted showing an increase of no less than 60 per cent. After the report had been adopted, a shareholder expressed his gratification that the company had got on so favourably, for, he remarked, "on first starting, matters were not so pleasant." Nor were they, as the chairman at once frankly admitted. But while it is not cheerful to make a bad beginning, it is better to have a bad beginning and a good continuation than *vice versa*, as is too often the case. It may reasonably be hoped that the shareholders of the German Union Company will have equal occasion for congratulating each other next year.

Possibly Mr. Abbott is waiting until next month, but, at any rate, the glowing reference we expected to see in his May circular to the West India and Panama Company is conspicuous by its absence. In fact, Mr. Abbott appears to have abandoned telegraph shares and gone in for railways, tramways, and, of all things in the world, hotel shares. The meeting of the company, which was held just too late for us to notice in the last number of the *Telegraphic Journal*, seems to have been of a satisfactory character. There was a time when the same remark could not, in any sense, be applied to the meetings of the West India and Panama Company. Then, the chairman referred to the fact, that for the first time in the history of the undertaking, the full amount of subsidies for the half year had been received, or was in course of payment. The reconstruction scheme has also been settled, and the liquidation process is at an end. We cannot say that the cost of the liquidation, namely £722, is extravagant. The West India and Panama Company has seen stirring times, and it is possible that the painful experience the shareholders have had to go through will warn them that their dividend can be materially influenced by good, or by bad, management.

It was but natural that the chairman of the Submarine Cables Trust should seize the opportunity offered him at the meeting of the company, to make a few complacent remarks on what he considers is the "success" achieved by the union of the Direct United State and Anglo-American Companies. Without qualifying by a word what we have over and over again urged respecting that amalgamation, we do not dispute that the Trust is begining to look up.

The secretary of the Direct United States Cable Company has given notice that the Board have resolved upon the payment of an *interim* dividend of five shillings per share, being at the rate of five per cent. per annum from the quarter ending March 31st. The dividend is payable after the 16th instant.

"In sympathy with the prevailing depression," writes one of the most enthusiastic believers in the "great future" of the Chatham and Dover Railway Company, "the price of the stocks of this railway remain at about the same level as they did last month." Yes; the anticipations of the gentlemen who made such a commotion at that Cannon Street meeting have still to be realised, even in part, and the South Eastern Company pursues the peaceful tenor of its way. Nor, although the new passenger steamer which the Chatham Company has just added to its fleet is a splendid boat—we regret to question whether at last "the attendant horrors of the Channel passage are completely overcome"—do we think that it will be the means of making the fortunes of the shareholders? This year will, of course, be an exceptionally good one.

The shareholders of the South Western Company are not persons to be envied at any time. It is possible that they may be envied less than ever shortly. For if the Board of Trade insists, as it ought to insist, upon the company raising the platforms of its stations, the outlay, which will be inevitable, may swamp the profits of the company.